U.S. DEPARTMENT OF COMMERCE
National Technical Information Service
PB-275 491

Journal Articles on Information Science

Environmental Protection Agency, Washington, D C

1975

Mother Sheet

PB 275 491

Title:

Journal Articles on Information Science

PB 275 492

PUBLICATION

256

Reprinted from
AMERICAN DOCUMENTATION
Volume 19, No. 2
April 1968

PESTICIDES PROGRAM
National Communicable
Disease Center
Atlanta, Ga. 30333

Computer Simulation of a Small Information System

This paper illustrates how computer simulation techniques can be used to simulate information systems. A computer program for a small system was written in GPSS V (a special simulation language) and run in an IBM 7090 Computer. The results obtained and the types of conclusions drawn are briefly discussed.

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• Introduction

Simulation is essentially a technique that involves setting up a model of a real situation and then performing experiments on the model. Shubik (*1*) defines simulation as the operation of a model or simulator which is a representation of some system. This model is amenable to manipulations that would be impossible, too expensive, or impractical to perform on the real system it portrays. The operation of the model can be studied and, from it, properties concerning the behavior of the actual system can be inferred.

It must be emphasized that simulation techniques are based on stochastic or probabilistic data and are best suited for those problems that cannot be solved easily by deterministic methods. In general, simulation techniques are applied in the following cases (*2*):

1. When it is either impossible or extremely costly to observe certain processes in the real world
2. When the observed system is too complex to be described by a set of mathematical equations
3. When it is impossible to obtain a solution to a mathematical model by analytical techniques
4. When it is either impossible or very costly to perform validating experiments on the mathematical models describing a system

Although the art of simulation has been known for many years, it is only since the early 1950's, with the advent of digital computers, that simulation has been applied to a variety of situations ranging from space flights to economic systems. Computer simulation techniques have been greatly enhanced with the development of special simulation languages such as SIMSCRIPT, GASP, DYNAMO, and GPSS III.

The purpose of this paper is to illustrate how one of these special languages, GPSS III, (*G*eneral *P*urpose *S*ystems *S*imulator) can be used to simulate the operation of an information system (3). Although the system simulated in this paper is hypothetical, it illustrates the capability of computer simulation techniques to simulate large, real-life systems.

• Example

Let us suppose that we are concerned with the operating efficiency of a small library branch at which customers arrive every 5 ± 2 time units, staying to use the library if the waiting line at the information desk contains less than nine persons, otherwise leaving. The girl at the information desk interviews each customer and, depending upon his needs, every customer is sent to one of two sections—the books or the reports section. It has been observed from past experience that the interviewing at the information desk takes 8 ± 3 time units, and on the average 70% of the customers are sent to the documents section and the remainder to the books section. The customers who go to the books section attempt to obtain the services of the only librarian in that section, provided there are no more than two persons waiting for service. Service time in this section takes 25 ± 5 time units, after which 40% of the customers leave while the remainder attempt to use a duplicating machine if the machine is not occupied. The average time required for duplicating is 45 ± 10 time units, after which the customers leave.

The customers who go to the documents section divide equally between two librarians, the first of whom re-

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quires 18 ± 3 time units for service, and the second 22 ± 4 time units. After service has been completed at this section, 75% of the customers leave while the remainder attempt to use a film reader, which is enclosed in a small room with a capacity of three persons. If this room is full, customers leave. The average time spent for film reading is 35 ± 5 time units, and when the service is completed, customers leave.

The operations of this library branch and the flow of customers in the system are summarized in Fig. 1. As seen from this figure, all customers enter the system at the same point but can leave from eight different points depending on their needs and their willingness to wait for service. The various system components are defined using GPSS III nomenclature:

Facility No. 1 = Information desk
Facility No. 2 = Books librarian
Facility No. 3 = Duplicating machine
Facility No. 4 = First documents librarian
Facility No. 5 = Second documents librarian
Facility No. 6 = Film reader
Storage No. 1 = Film reader room with a capacity of 3 persons

The waiting lines associated with these facilities are referred to as queues; for example, Queue No. 1 will be the waiting line for the information desk, Queue No. 2 for the books librarian, etc.

Some of the data that can be obtained from this program are as follows:

1. The average percent of utilization of each facility, i.e., the percent of time that each facility was occupied
2. The average time per customer spent at each facility
3. The average and maximum number of customers in each waiting line.
4. The number of customers who did not have to wait in line, i.e., the facility was empty when they arrived there
5. The average time each person had to wait in line.

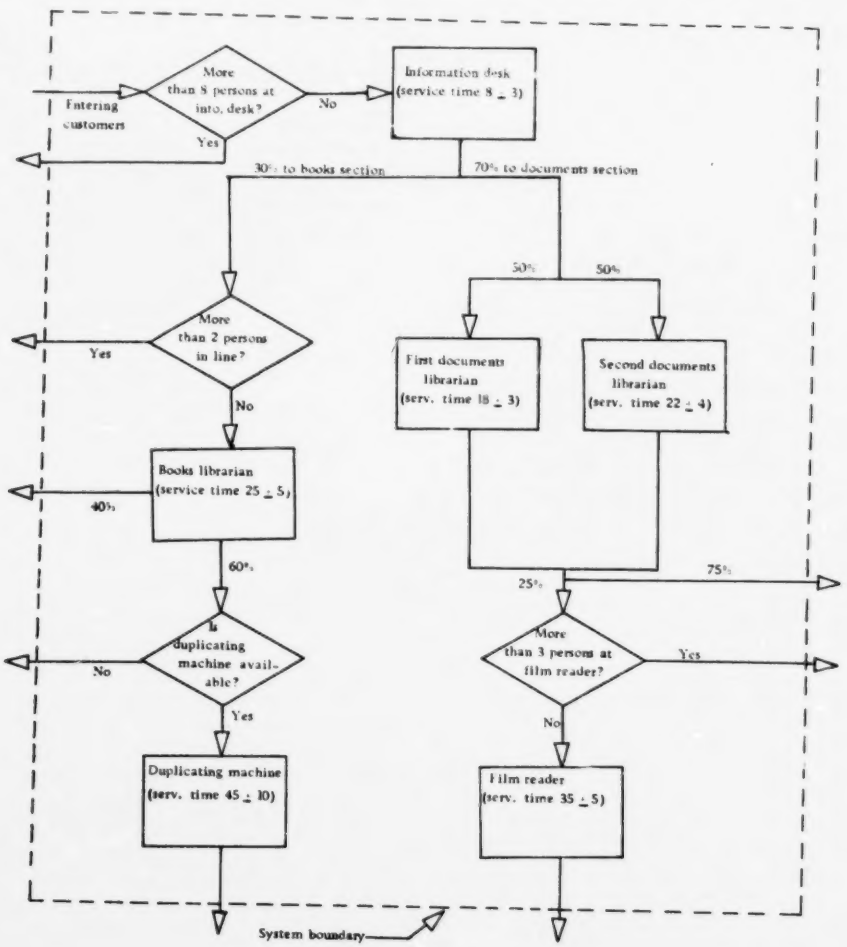

FIG. 1. Schematic diagram of the system

• Results

For the purpose of his example, the arrival of 174 customers was simulated, including 55 who left the system as soon as they entered because the waiting line at the information desk was too long. At the end of the simulation run, 100 customers had gone through the system, while 19 customers were at various points throughout the system. Some other typical items of information obtained from the computer simulation are as follows:

1. Only one customer of those who wished to go to the books section left the system without being able to obtain service.
2. Of the 18 customers who wished to use the duplicating machine, only 2 were unable to use it.
3. All the persons wishing to use the film reader were able to do so.
4. The number of customers who went to each of the three librarians was as follows:

Books librarian —32
First documents librarian —41
Second documents librarian—35

The books and the first documents librarians were serving one person each at the end of the simulation run, while the second documents librarian was also serving one customer and had three more waiting in line.

A summary of some of the data obtained from this simulation is given in Table 1. These data are only illustrative of the type that can be obtained in a computer simulation. It is quite obvious how such data can be used to improve the efficiency of a system. Facilities can be added where needed, service times can be reduced, etc., in an attempt to achieve as high utilization as possible with a minimum of time spent in waiting lines. In this hypothetical system, for example, the information desk (Facility No. 1) creates a bottleneck, since, on the average, persons had to wait in line for 57.88 time units, and 55 persons left the system before reaching the desk. The situation can obviously be improved by adding another information desk or by eliminating this component all together. On the other hand, it would be useless to add a second film reader (Facility No. 6), since all of the customers wishing to use the film reader were able to do so.

In short, simulation is a powerful technique that can be used effectively not only to improve existing systems but also to design new ones. Computer simulation is particularly well suited for analyzing information systems, since these systems are normally too complex to be described and analyzed mathematically.

• Acknowledgments

The author wishes to thank the Georgia State College of Business Administration, Atlanta, Georgia, for running the computer program. Thanks are also due Mrs. Pat Chandler of the Redstone Scientific Information Center, Redstone Arsenal, Alabama, for typing the manuscript.

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2. Naylor, Thomas H., Joseph L. Balintfy, Donald S. Burdick, and Kong Chu, *Computer Simulation Techniques*, John Wiley & Sons, Inc., 1966, pp. 6–7.
3. *General Purpose Systems Simulator III, User's Manual*, IBM Application Program Form H-20-9163-1.

Table 1. Summary of results

Facility No.	Average % of utilization	Average service time per person	Average No. of persons in queue	Maximum No. of persons in queue	No. of persons not having to wait in line	Average time persons had to wait in line
1	89.57	7.88	7.12	9	2	57.88
2	82.95	25.09	.86	3	5	25.94
3	76.65	46.88	.68	2	3	41.44
4	77.27	18.24	.82	4	6	19.41
5	69.01	21.55	.74	4	6	20.57
6	58.37	33.24	.22	2	6	11.78

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Indexing from Abstracts of Documents

PB 275 493

PUBLICATION

228

PESTICIDES PROGRAM
National Communicable
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Received July 27, 1967

Two types of abstracts, informative and indicative, as well as entire documents, were investigated as to their content of significant words for the selection of index terms. The results indicate that abstracts compare favorably with entire documents as sources of index terms. In the case of informative abstracts, approximately 71% of the terms selected from documents were also contained in their abstracts.

Automatic indexing, a term usually applied to machine extraction of index terms from text, has been the subject of considerable study in the past decade. The primary aim in automatic indexing is to derive index terms directly from the text with a minimum of human intervention. The text may consist of the entire document, the abstract, the title, or any combination of these.

Computer indexing has been proposed not only in an effort to cope with the continuously increasing volume of material that must be indexed, but also to overcome some of the inadequacies of human indexing. Studies of the consistency of human indexing indicate that the agreement among a group of indexers who index the same document (inter-indexer consistency), and even the agreement within the same indexer who indexes the same document at different times (intra-indexer consistency), are

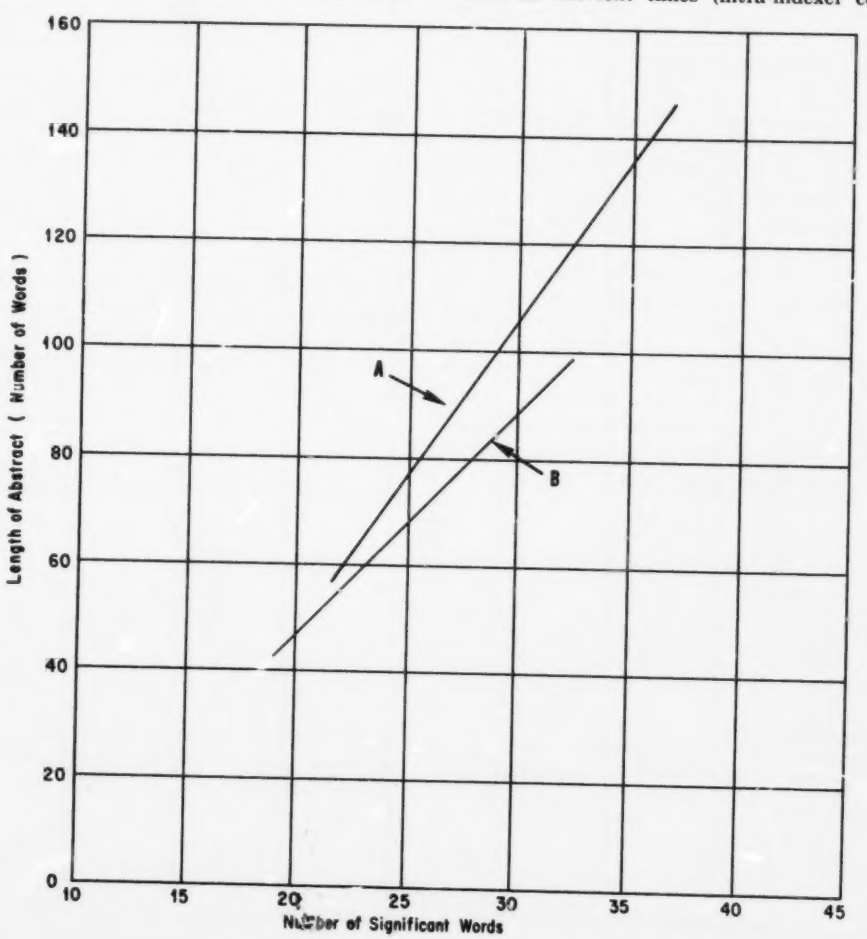

Figure 1. Length of A and B abstracts vs. number of significant words

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Information Activities in Support of the EPA Pesticide Program†

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Received November 5, 1975

The Environmental Protection Agency (EPA) is responsible for regulating the supply and use of pesticides. The EPA Office of Pesticide Programs (OPP) is involved in (1) supply control via product registration, (2) use control, (3) monitoring and hazard evaluation, and (4) research and economic studies. Major information activities in support of these four activities are reviewed.

The Environmental Protection Agency (EPA) is a regulatory agency. Among its familiar programs, such as those directed toward cleaner air and purer water, is another, Pesticides, which constitutes somewhat of a special interest in connection with the first two, and has potentially far-reaching implications for the world's agricultural community as well. Indeed, pesticides have brought substantial benefits to man. Yet, these benefits to our health, welfare, and comfort, which arise from using chemical compounds to control undesired forms of animal, plant, and microorganism species, are sometimes offset by the adverse effects that they also can have on man and the environment.

With the passage in 1972 of an amendment to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1947, EPA was given broad new powers and responsibilities to regulate the supply and use of pesticides so that, with the desire for ever more benefits, and the urge of the marketplace to provide them, sufficient attention is given to minimizing the negative consequences as well.

FIFRA, with the 1972 amendments, is a comprehensive new law. It provides for Federal regulation of all pesticide products that are marketed and used within the United States, while preserving the right of the States to regulate products within their own boundaries. It assures a more complete scientific review of pesticide products, so that the circumstances of their use are designed to minimize the potential for creating undesired adverse effects. It provides for denying use when the expected or observed hazards of such use far outweigh the benefits, and it incorporates penalties for misuse. It provides for training those who intend to use highly toxic products and those who apply pesticides as a commercial service. It seeks more descriptive and understandable product labeling, so that information on proper care and use may be communicated more effectively. It also provides for specific responses to special or emergency needs, by permitting use of certain chemicals under highly controlled conditions.

While the foregoing list of provisions is by no means complete, it does serve to highlight most of the major ones and provide some background for a discussion of EPA's Pesticide Program and the information activities that are emerging to support it. A diagram of the process of product registration and regulation is shown in Figure 1. Applicable sections of the FIFRA are shown for the major activities.

The EPA component responsible for conducting the program to carry out FIFRA is the Office of Pesticide Programs (OPP). Toward this end, OPP has developed a four-point strategy through which the program is divided into major thrusts and under which it is actually conducted. These four points are:

1. Register and classify all pesticide products to identify more precisely those that can be safely and effectively used.
2. Provide more fully for the safety of pesticide use and facilitate improved product labeling, packaging, and education programs to reduce unwarranted adverse effects due to misuse.
3. Improve hazard evaluation activities and the monitoring programs that are necessary to support them.

† Presented in the symposium on "Information Requirements Resulting from Environmental Impact Laws", Division of Chemical Information, 170th National Meeting of the American Chemical Society, Chicago, Ill., Aug 27, 1975.

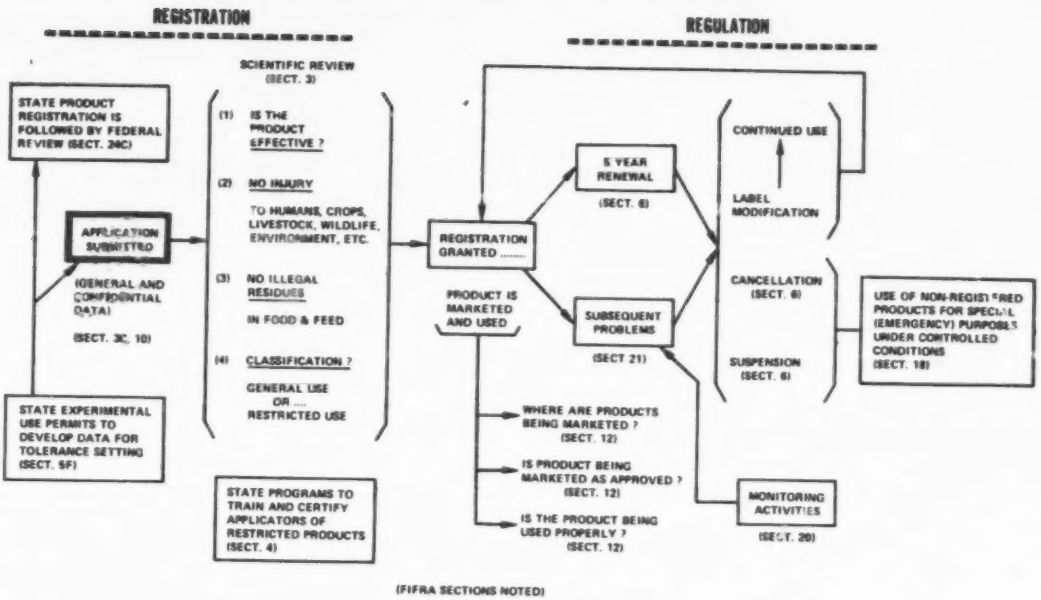
THE REGISTRATION AND REGULATION OF PESTICIDE PRODUCTS
REGISTRATION
REGULATION
SCIENTIFIC REVIEW (SECT. 3)
STATE PRODUCT REGISTRATION IS FOLLOWED BY FEDERAL REVIEW (SECT. 24C)
APPLICATION SUBMITTED
(GENERAL AND CONFIDENTIAL DATA) (SECT. 3C, 10)
STATE EXPERIMENTAL USE PERMITS TO DEVELOP DATA FOR TOLERANCE SETTING (SECT. 5F)
(1) IS THE PRODUCT EFFECTIVE ?
(2) NO INJURY TO HUMANS, CROPS, LIVESTOCK, WILDLIFE, ENVIRONMENT, ETC.
(3) NO ILLEGAL RESIDUES IN FOOD & FEED
(4) CLASSIFICATION ? GENERAL USE OR ... RESTRICTED USE
STATE PROGRAMS TO TRAIN AND CERTIFY APPLICATORS OF RESTRICTED PRODUCTS (SECT. 4)
REGISTRATION GRANTED .....
PRODUCT IS MARKETED AND USED
5 YEAR RENEWAL (SECT. 6)
SUBSEQUENT PROBLEMS (SECT 21)
CONTINUED USE
LABEL MODIFICATION
CANCELLATION (SECT. 6)
SUSPENSION (SECT. 6)
USE OF NON-REGISTERED PRODUCTS FOR SPECIAL (EMERGENCY) PURPOSES UNDER CONTROLLED CONDITIONS (SECT. 18)
WHERE ARE PRODUCTS BEING MARKETED ? (SECT. 12)
IS PRODUCT BEING MARKETED AS APPROVED ? (SECT. 12)
IS THE PRODUCT BEING USED PROPERLY ? (SECT. 12)
MONITORING ACTIVITIES (SECT. 20)
(FIFRA SECTIONS NOTED)

Figure 1.

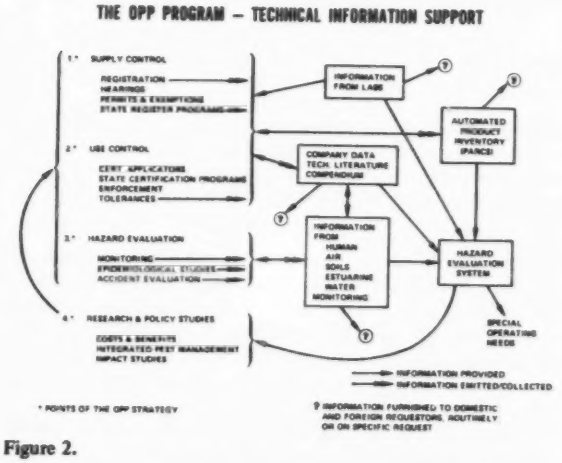

Figure 2.

4. Improve methods for regulating pesticides by increasingly taking into account technological, economic, organizational, social, and physical characteristics in the environment of pesticide use, and the changes occurring in that operating environment.

These four major points—(1) improving control of the supply and (2) use of pesticides, (3) improving hazard evaluation and monitoring activities, and (4) perfecting our understanding of the total benefit and risk picture—require a very substantial information support effort.

Figure 2 illustrates the major features of this effort and associates them with activities that fall under the four points of the OPP strategy. Notice particularly how the information collections interact and how their use is concentrated by the Hazard Evaluation System (HES) to help support major studies that may affect, in due course, the conduct of the Pesticide Program itself.

The information activities shown in Figure 2 fall into several broad categories. They involve:

1. Technical Literature—Locating, collecting, storing, and retrieving pertinent articles on pesticides and related subject matter from the world's technical literature;
2. Pesticides Registration Data—Storing and retrieving data that result from the product registration process and technical data that are submitted by pesticide registrants in support of their products;
3. Laboratory and Monitoring Data—Collecting and supplying data from the laboratory and monitoring activities of OPP and other components of EPA;
4. Current Awareness Activities—Developing and using current awareness publications and services and sharing information with U.S. and foreign governments and private sectors;
5. Information Support Services—Furnishing editorial services, printing coordination, and reprint distribution for technical papers and reports, and conducting the Federal Register liaison program—and the Freedom of Information program (locating and delivering specific materials to requesters under provisions of the Administrative Procedures Act).

The OPP component that provides services within these categories is the Technical Services Division (TSD). The following is a brief description of each with comments on the current status of developing projects, as appropriate.

1. Technical Literature. A pesticide information center is maintained by TSD to provide literature searches, prepare bibliographies, and supply abstracts or full text copies on request. The center is also the focal point for handling reference books, periodicals, and articles that are specific to pesticides. [The Hayes–Lewis collection, named for its two initial builders, Dr. Wayland J. Hayes and Claudia Lewis, was moved to EPA in Washington, D.C., from the U.S. Public Health Service Pesticide Toxicology Laboratory at Chamblee, Ga., in 1973, as part of a reorganization to strengthen the Federal environmental programs.] Holdings consist of about 1000 text books, manuals, and proceedings, and subscriptions to approximately 100 journals that contain an estimated 60% of the total pesticide literature. An in-house collection of articles on pesticides is also maintained.

TSD maintains a contract under which the world's literature is scanned for articles pertinent to this collection. Selected articles are abstracted, published in *Pesticides Abstracts* (PESTAB) [formerly *Health Aspects of Pesticides Abstract Bulletin* (HAPAB)], and added to the collection as the hardcopy is received. These articles, collected since the early 1950's, currently number approximately 30,000 and represent one of the more comprehensive collections on pesticide toxicology and health effects in existence.

The Hayes–Lewis collection was originally cataloged in a manual card file. Recently, a computer-based catalog was developed and most of the 30,000 citations have been converted to this system. Multiple indexes (compound and concept coordinates are used to classify the articles) are run and generated to paper output and COM. This system has been fully tested and will be operational early in 1976. All articles exist as classified citations, with abstracts next to be entered. Text search will be supported. All articles are being microfilmed. The indexes on COM, which provide access by compound, concept, and author, provide sufficient specificity to replace on-line searches in most cases.

The center also queries external data bases, such as *Chemical Abstracts*, *Biological Abstracts*, CAIN, HEEP, Toxline, Medline, and Cancerline, etc., on a routine basis. Library facilities in the neighboring Federal community (e.g., Food and Drug Administration; Agriculture Department; Health, Education and Welfare Department; and the Interior Department) are contacted for hardcopy when appropriate.

2. Pesticides Registration Data. Several types of data are gathered during the registration process, and are committed to manual and automated inventories to support registration and other activities within and outside the Pesticide Program. These data include:

Registration chronology and status
Technical profile of the pesticide products
Use pattern (site/pest)
Use limitations and precautionary information
Name and address (of the registrant)
Technical data submitted by the registrant in support of the registration/amendment request

Much of these data are obtained from the product label. The balance is supplied in other forms by the registrant or generated in the registration process itself. An automated inventory system (PARCS) [Pesticide (product) Analysis Retrieval and Control System] for label and certain other data is being enlarged to support various search, process control, and reporting requirements using hardcopy and COM outputs. A set of product indexes that provide access to all registered products by chemical, site, or pest, are being produced via COM by the PARC System. These microfiche indexes are distributed to EPA regional personnel, and State extension and regulatory personnel through the USDA Extension Service. Company data supplied in support of registrations is classified, accessioned, and archived in a large storage facility, and will be retrieved through computer searches of the label, company data, and accession files. For processing efficiency, the automated files are segmented into the following components:

Label data files (active and inactive)
Product name files (active, pending, inactive, and distributors)
Company data file
Site/pest file of coded use patterns for each product

Also, for storage efficiency, various vocabulary (look up) files are used, for example:

1. Site (host locations to the pests)
2. Pest (common and scientific nomenclature)
3. Chemical cross-reference index
4. Company name and address file

3. Laboratory and Monitoring Data. TSD operates a National Pesticides Monitoring Program to detect and measure residues in humans, soil and crops, surface waters (with U.S. Geological Survey), air, estuarine fish and shellfish, and ocean fish (with NOAA). These data support decisions in public hearings, experimental use permits, emergency exemptions, and pesticide registration and classification.

The Epidemiologic Studies Program defines the nature of chronic effects of pesticides on environmentally or occupationally exposed populations, characterizes the magnitude of U.S. pesticide usage, and provides health and environmental effects data on experimental chemicals prior to registration. Special studies performed by this Program include analyses of protective clothing for applicators and the determination of reentry times for field workers after pesticide application.

TSD also performs chemical and biological investigations to support the registration procedure as well as HES. Several labs perform chemical, toxicological, and efficacy tests, and provide rapid analytical services for accidents. They also ensure a high level of scientific competence in other laboratories whose functions are to supply chemical data for enforcement purposes and develop standard methods for all aspects of pesticide formulation analysis by conducting training seminars, developing manuals of laboratory methods, supplying standard references for pesticides, and assisting in contested actions.

4. Current Awareness Activities. The Office of Pesticide Programs is currently publishing several periodicals and documents that relate to the Pesticide Program. All are available to users within and outside the U.S. Government.

One of these periodicals is *Pesticides Abstracts*. It was designed to assist the scientific community and others in keeping abreast of the latest information available on various aspects of pesticides and provides abstracts of current pertinent literature including papers written in foreign languages. This publication is in accord with measures frequently urged by Congress and the Executive Branch to meet the increasing overall need for dissemination of scientific and technical data. Publication of this periodical began in September 1968. Approximately 250 abstracts are being published monthly under contract with the Franklin Institute Research Laboratories. Criteria for selection of articles were developed with input by various professional personnel within the Pesticide Program. The Bulletin consists of five different sections: General; Monitoring and Residues; Epidemiology, Prevention, and Treatment; Toxicology and Pharmacology; and Analysis. Subject and author indexes are published quarterly in the March, June, and September issues, and an annual cumulative subject and author index is published as a separate issuance distributed at approximately the same time as the December issue.

The Toxicology Information Program of the National Library of Medicine is entering these abstracts in the on-line Toxicology Information System (Toxline) which is now available to the public via terminals.

The *Pesticides Monitoring Journal* (PMJ) is a primary interdepartmental publication and has been published since June 1967 under the auspices of the Federal Working Group on Pest Management. The PMJ was an outgrowth of one of the recommendations of the 1963 Report of the President's Science Advisory Committee that concerned agencies develop a continuing network to monitor residue levels in man and the environment.

In response to this recommendation, the Working Group established a Monitoring Panel who designed an early pesticide monitoring program which was supported by the member Federal agencies. The Journal was established principally to provide a single outlet for publication of data emanating from

the monitoring program but also to serve as the publishing medium for other pesticide monitoring efforts in this country. Contributions from foreign countries are also invited, and data from a number of these programs have been reported in the Journal.

Official subscriptions to both of these periodicals are provided to about 800 individuals and organizations, including members of EPA and other federal agencies, state and local governmental agencies, hospitals, universities, private research institutions, and industry. Both PMJ and PESTAB are also available through paid subscriptions from the Government Printing Office.

TSD also prepares and distributes a monthly current awareness issuance listing new articles, books, translations, and bibliographies on pesticides accumulated from all sources. Approximately 250 items are listed each month. A document delivery form is provided for users to request articles in microfiche or hardcopy. This publication is distributed to 250 users each month, many of whom are EPA personnel.

One of the most widely used documents in the pesticides community is the *Compendium of Registered Pesticides*. This document is currently being built and published in five volumes and is now partially available with supplements by subscription from the U.S. Government Printing Office. The volumes are:

Volume I	Herbicides and Plant Regulators
Volume II	Fungicides and Nematicides
Volume III	Insecticides, Acaricides, Molluscicides, and Antifouling Compounds
Volume IV	Rodenticides and Mammal, Bird, and Fish Toxicants
Volume V	Disinfectants

The Compendium is based on a review and compilation of use-pattern data from approved labels, and is organized primarily by chemial/site/pest, with suitable cross-indexing for access by site and pest. The PARC System (label and site/pest file) is used to provide organized resource material for use in the primary review of chemical and site groups for publication in the Compendium.

A companion publication, the *Greensheets*, is published as a notice of the registration of new chemicals and other material of critical interest to the external pesticide community.

5. Information Support Services. TSD also maintains an editorial staff and a system for ordering, distributing, and storing publications resulting from activities of the Office of Pesticide Programs. These publications are listed chronologically in a brochure, *List of Publications—Office of Pesticide Programs*, with supplements issued periodically. About 1000 reprints of each publication are distributed on mailing lists representing the same audience described above in the discussion of the periodicals. Additional copies are stored for use in responding to public inquiries on various health and other aspects relating to pesticide use.

The *Federal Register* is the major current awareness publication covering noteworthy matters that involve the daily operations of the Executive Branch. OPP submits materials on a virtual daily basis for publication in the Register, including various regulations, notices involving registration, tolerance, and exemption actions. TSD provides the editorial and liaison functions as a part of the information program.

Some requests for information, primarily those that are concerned with data that are supplied by registrants in support of their registration requests, must be handled using procedures contained in the U.S. Freedom of Information Program. Since some parts of these data may be proprietary, the specifics of these requests are passed through the submitting company and the EPA General Counsel to obtain release authority. Data not cleared for release are retained pending legal resolution of the conflicting interests.

Having briefly described the law, the program strategy, and the major information activities, we return now to Figure 2 to comment on the relationships between these activities and the program they must support.

SUPPLY CONTROL

The registration process emits data to the PARC System (to update the product inventory) and consumes information from the labs (chemical, toxicological, and efficacy tests), the company data files and Compendium (to establish acceptance rationale and registration use-pattern precedent, and, with the technical literature files, to develop registration criteria). This Federal registration activity is also a pattern for that conducted in the States, and state registrations are subsequently reviewed for acceptance at the federal level. Information exchange between these levels is being explored at the present time.

The hearing process affords the public sector an opportunity to enter into open debate with EPA on the merits and effects of various regulatory actions that involve removal of registered products from the marketplace. All information sources are tapped by the Agency (and the public sector through the FOI program) to support this debate.

The permit and exemption programs exist to provide for use of nonregistered pesticide compounds under controlled conditions for specific purposes. Experimental Use Permits (FIFRA, Section 5) provide for testing pesticide compounds on food and feed commodities so that residue tolerances may be established prior to accepting such new products or use patterns in the normal registration process. States may also grant these permits for their own special local needs. The Exemption provision of FIFRA (Section 18) provides that federal agencies may apply nonregistered pesticide compounds under controlled conditions in emergency situations.

In addition to tracking approved tolerances, the PARC System provides information from the product inventory to assure that the permit or exemption requests have not already been covered by a registration, so that these processes can avoid producing costly and duplicative documentation to justify uses that are already covered by registered products.

USE CONTROL

The registration process includes a determination of product toxicity. Products that pose a major threat to humans and the environment if handled or applied incorrectly are classified as "restricted" and may be applied only by certified applicators or individuals under their direct supervision. FIFRA (Section 4) provides for state applicator training and certification programs, and for federal approval of the state programs. The PARC System provides counts of the toxic products so that training programs can be geared to those most commonly used, and the technical literature and company data files yield information used to help develop training criteria and training guide materials.

The enforcement process uses registration information from the PARC System and copies of labels provided on microfilm to track misbranding and misuse cases.

PARCS also provides product indexes by chemical, use pattern, registrant, etc., to support pesticide recommendation activities conducted throughout this country by the USDA Extension Service.

The tolerance setting process uses technical literature and company data in the evaluation of acceptable residue levels.

HAZARD EVALUATION

A Hazard Evaluation System is being developed to provide for a total context assessment of hazard to humans and the environment resulting from use (and misuse) of pesticides.

This system seeks to integrate information from the laboratories, monitoring activities, technical literature, company data, the registration process itself, and other federal activities, in addition to various contract research studies.

RESEARCH AND POLICY STUDIES

All regulatory activity results in varying degrees of cost and benefit to diverse interests within the public sector. The intent is to maximize benefit and minimize cost.

In order to make this intent as much of a reality as possible in the Pesticide Program, OPP is conducting and supporting scientific research and policy studies directed both at providing support for pesticide regulatory actions and toward establishing a firmer understanding of pest control methods as they impact man and the environment. These activities are composed of a variety of both short- and long-term investigations and are being carried out in several broad areas:

Pesticide effects
Alternative pest control methods
Laboratory methods and quality control
Pesticide wastes recovery and conversion
Cost/benefit assessment methods
Unreasonable adverse effect assessments
Monitoring optimization
Identification of new research needs
Evaluation of interrelationships between pesticides and other pollution statutes and programs.

These activities consume information from all OPP sources, channeled through the Hazard Evaluation System, or obtained directly from the sources as needed. Contractor personnel are involved in some of these studies, and draw for their work on OPP and external sources. Research and study results are usually published by OPP or are made available to the public sector under the FOI program.